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On Various Porous Scaffold Fabrication Methods

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Abstract

Three-dimensional scaffolds can be fabricated by various methods. These scaffold constructs showed a major impact on various biomedical applications. The bioactive porous scaffolds should have an excellent three-dimensional architecture and interconnected porous structure for cells adhesion and migration to enhance the therapeutic potential. The porosity and interconnected porous structure can be optimized using various scaffold preparation methods. In this mini review, we discussed the advantages and disadvantages of various commonly used scaffold preparation techniques.

Keywords: Three-dimensional scaffolds; Scaffolds; 3D Scaffold; Scaffold Constructs; Porous scaffolds

1. Introduction

Three-dimensional scaffolds has a key role in various drug delivery and tissue engineering applications[1]. Tissue engineering using three-dimensional porous scaffolds is an emerging multidisciplinary research area to regenerate the organs and tissues which have been lost or defective by various pathological conditions [1], [2]. Design and fabrication of the three-dimensional scaffolds are most important area in tissue engineering applications [3].In general, the tissue engineering constructs should posses a

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range of key factors such as biodegradability, biocompatibility, mechanical properties, an interconnected porous structure with high porosity *etc*[4]. The biodegradable polymeric porous scaffolds helps for cell adhesion and tissue development subsequently [5]. These three-dimensional scaffolds can be fabricate by various methods [6].

2. Scaffold Fabrication Methods

In order to prepare the commercially feasible tissue engineering construct supposed to be as cost effective as well as clinically effective [4]. Among various scaffold fabrication techniques, the most commonly using scaffold fabrication techniques are discussed here.

2.1 Solvent Casting

Solvent casting is the simple and cost-effective method to synthesize the scaffolds [7]. There are two ways to prepare the scaffolds using solvent casting method such as (i) the polymeric scaffold layer can be formed by dipping the mold into the polymeric solution, (ii) the prepared polymeric solution can be added into the mold followed by solvent evaporation step to form the polymeric scaffold layer [8]. This method has the limitations due to the toxicity of the solvents used in the scaffold preparation process. Addition of particulate leaching technique to this solvent casting method helps to overcome the limitations of this method [6], [9], [10].

2.2 Particulate Leaching Technique

Particulate leaching technique has been using widely to prepare the scaffolds with the porous structure for numerous tissue engineering applications [11], [12]. Salts, wax and sugars can be used as porogens to form the porous structure during the scaffold preparation process[7]. In this method, the polymeric solution is transferred into the mold contains the porogens followed by the solvent evaporation to prepare the polymeric scaffold layer. The porogens are leached out using repeated water washing results porous architecture in the prepared scaffolds. But the porous structure and inter-pore connectivity cannot be controlled using this technique, so the researchers are started to develop the new technologies to make the scaffolds with uniform porous structure [13].

2.3 Gas Foaming

Gas foaming method was developed to overcome the limitations of solvent toxicity in scaffold preparation methods[1]. In this method, the carbon dioxide gas has been using as porogen to make the porous structure in scaffold fabrication process [6]. The porous structure of the scaffolds depends on the carbon dioxide dissolved in the polymeric solution [14]. This technique results unconnected porous architecture in prepared scaffolds and also it makes difficult in seeding and migration of the cells within the prepared porous scaffold. The guided interconnected porous structure can be obtained by adding the particulate leaching method into this gas foaming process [15].

2.4 Phase Separation

In this phase separation methods, the polymer is dissolved using phenol or naphthalene followed by lowering the temperature results separation of prepared polymer solution into two phases such as low polymer concentration (lean phase) and high polymer concentration (polymer rich phase) [16], [17]. The used solvents are removed by extraction, evaporation and sublimation process results porous structure in the prepared scaffolds [8], [14].Phase separation techniques has various types such as solid-liquid, thermally-induced and liquid–liquid phase separation[1].

2.5 Freeze Drying

The scaffolds with porous structure can be formed using this freeze drying methods [18]. Controlled porous structure can be obtained with various freezing temperature [1]. Freeze drying method does not necessitate high temperature and leaching out process, but this technique consumes more time and also it has limitations to prepare the scaffolds with hierarchical structures [19], [20].

2.6 3D Printing

3D printing technique helps to engineer the scaffolds with consistent and adequate pore size and also an interconnected pore networks compared to other scaffold preparation techniques [1], [21]. In recent years, stereolithography, fused deposition, modeling, selective laser sintering, inkjet printing and colorjet printing techniques are gathered more consideration. These techniques has capability to prepare the three-dimensional scaffolds using plastics [21].

3. Conclusion

The three-dimensional porous scaffolds have been developed using various fabrication techniques such as solvent casting, particulate leaching technique, gas foaming, phase separation, freeze drying, 3D printing *etc* for several biomedical applications. These engineered scaffold constructs provides excellent biocompatibility and mechanical support to deliver the cells and bioactive molecules to the defected site. In this short review, we discussed the merits and demerits of some important and most commonly used scaffold fabrication methods. In conclusion, several bioactive molecules can be incorporate into the porous scaffolds to make the bioactive three-dimensional scaffolds for various drug delivery and tissue engineering applications.

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